Managing the integrated direct and indirect life-cycle impacts of sewers and WWTPs in Mediterranean and Atlantic cities

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1 Introduction and objectives

A sustainable operation of sewers and Wastewater Treatment Plants (WWTP) is essential to meet the demand of an increasing urban population. So far, studies have focused on the impacts of operating WWTPs, and few of them have analysed sewers. Wastewater degradation is a potential source of Greenhouse Gas emissions (GHG) such as methane (CH_4) and nitrous oxide (N_2O), which have a Global Warming Potential (GWP) of 28 and 298 $kgCO_2/kg$, respectively [1].

The goal of this study was to **integrate and compare the direct and indirect GHG of operating sewers and WWTPs under Mediterranean and Atlantic conditions** (Figure 1).

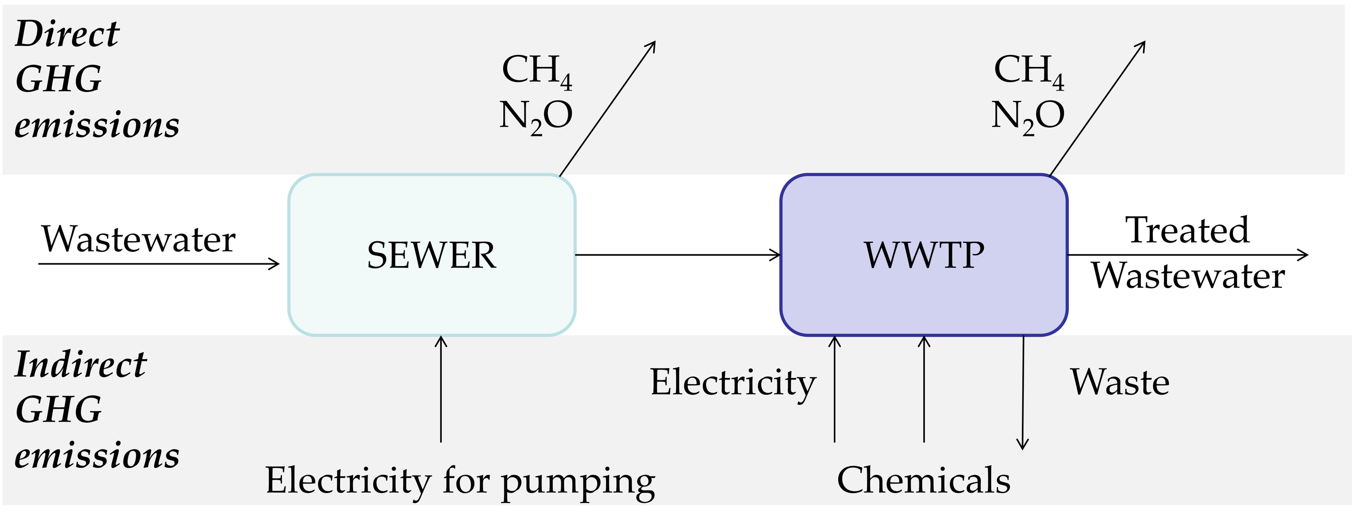

Figure 1. Diagram of the system boundaries

2 Methodology

To account for the direct and indirect GHG of the system (Figure 1), data on process flows (Table 1) and direct emissions were collected.

Case studies: Mediterranean climate → Calafell (Catalonia, Spain)
Atlantic climate → Betanzos (Galicia, Spain)

Sampling campaign: Summer 2013 and Winter 2014. Gas emissions were monitored with a gas tube or a closed chamber during 1 hour in:

- **Sewer:** 5 sites (manholes, wet wells in pumping stations and influent of the WWTP)
- **WWTP:** all treatment stages

Life Cycle Assessment (LCA) [2] was used to quantify the environmental impacts of the inputs and outputs of the system (Table 1). The database ecoinvent 2.2 [3] was used, linked to Simapro 7.3. The impact assessment method was CML 2 baseline 2000 V2.05.

Functional Unit: 1 m^3 of treated wastewater

Table 1. Inventory of the inputs and outputs related to the indirect GHG emissions

	Flow	Betanzos		Calafell	
		Summer	Winter	Summer	Winter
Sewer	Electricity (kWh)	3.9E-02	7.8E-02	2.2E-01	4.0E-01
WWTP	Electricity (kWh)	3.9E-01	6.0E-01	3.6E-01	5.5E-01
	Chemicals (kg)	9.6E-04	1.5E-03	9.1E-03	2.4E-03
	Transport (kgkm)	5.6E+01	1.1E+02	1.6E+02	1.6E+02
	Waste management (kg)	6.3E-02	9.8E-02	3.8E-02	6.0E-02

3 Results and Discussion

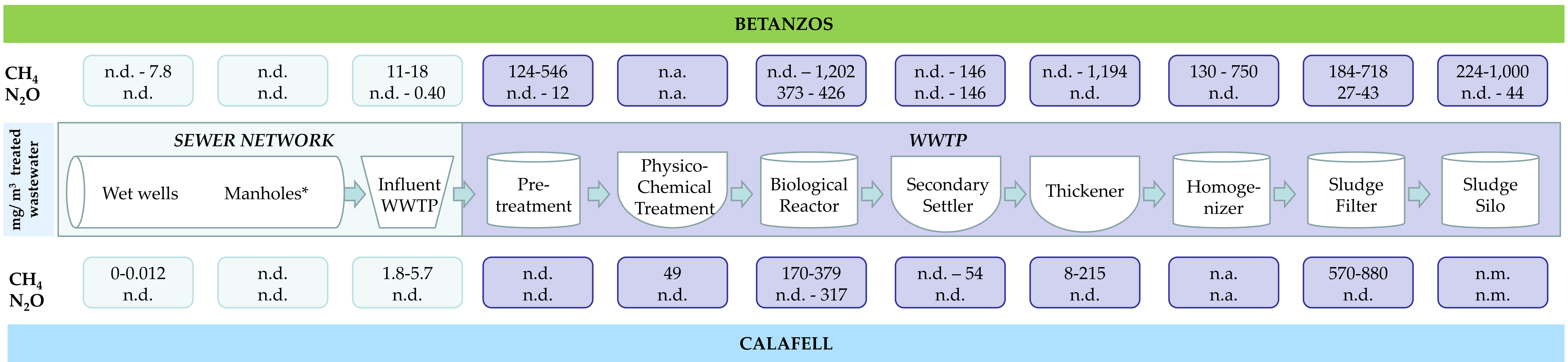

Figure 2. Range of direct GHG emissions measured in different sites. The results are an average of the summer and winter sampling campaigns. n.d.: not detected Detection limit (ppm_v)= 2; n.a.: not available, treatment step not present in the WWTP; n.m.: not measured
** No emissions because the air was still during the sampling campaign. Gas concentrations were found, but gas emissions were not.*

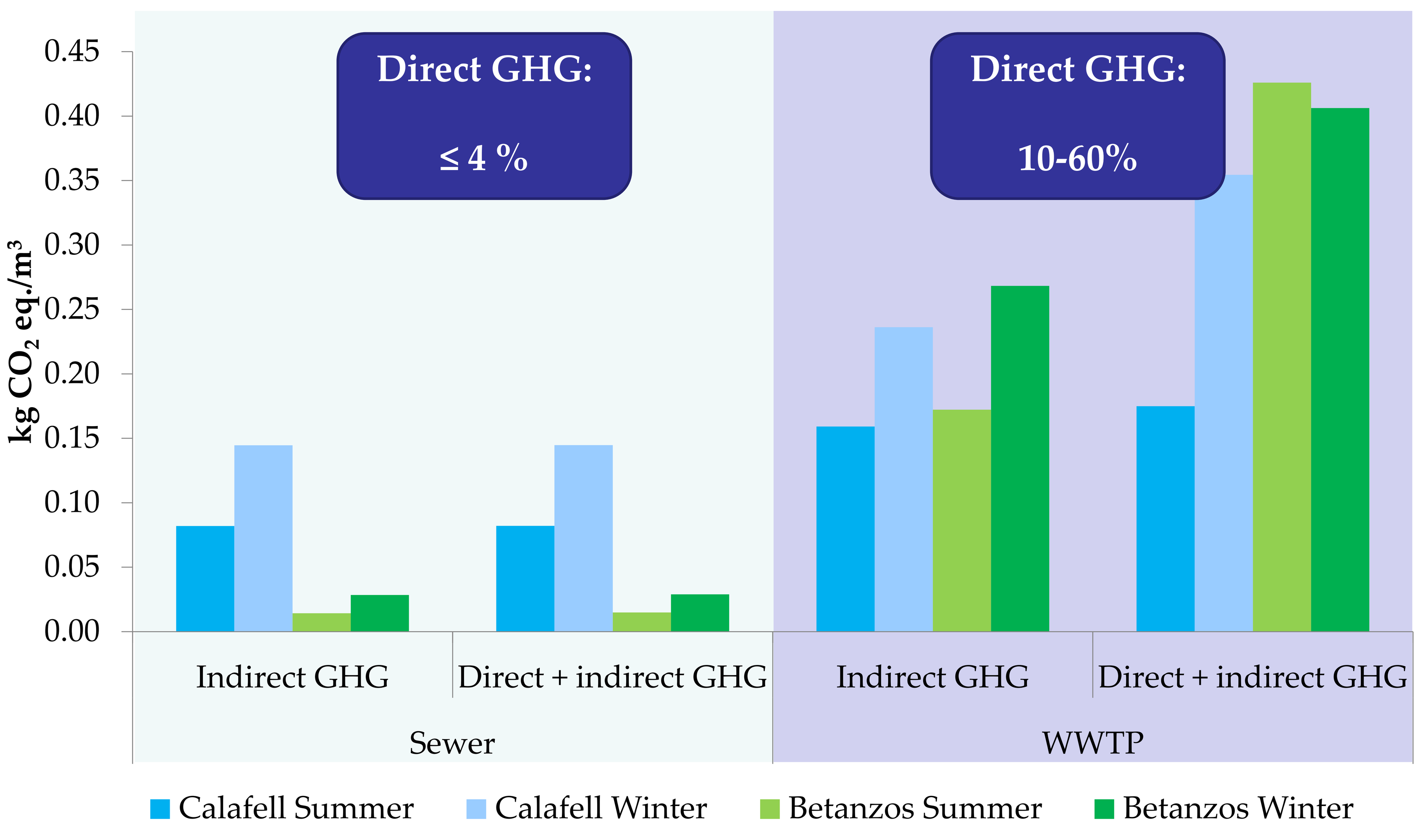

Figure 3. Integration of direct and indirect GHG emissions of the operation of sewers and WWTPs

After conducting the analysis, it was observed that:

(1) The integration of emissions from sewers and WWTPs is not straightforward when accounting for the direct emissions. In this study, only the emissions of 5 sites in sewers where considered for sampling purposes (Figure 2). Although only the emissions of these sites were included, the results suggest that they can represent up to 4% of the operation impacts of sewers (Figure 3), which is not irrelevant, considering that **this system has more potential emitting sites**.

(2) In general, the importance of including direct GHG in the LCA of WWTPs was clearly demonstrated (Figure 3). **Overlooking these emissions would lead to an underestimation of 13-33%** of the total emissions. In Betanzos and Calafell, the contribution of the direct GHG to the total emissions represented 0.201 and 0.072 kg CO_2eq./m^3, respectively.

(3) Compared to WWTPs, the total impacts of sewers are smaller, but in Calafell they account for **30% of the GHG of the entire sanitation system**. In this case, the differences are due to the pumping requirements, which are greater in Calafell than in Betanzos. Regarding the impacts in different times of the year, the emissions per m^3 were greater in winter than in summer because the wastewater production increases in the latter due to seasonality.

4 Conclusions

Sewers and WWTPs are sources of CH_4 and N_2O and these gases result in relevant contributions to the environmental impacts of operating both systems. However, future studies should focus on developing gas production models, especially in sewers, in order to account for all the emissions that take place in this system. This approach would provide a more accurate estimation of the importance of sanitation systems on global GHG emissions and give urban planners guidance on how to manage and design future infrastructures from a life cycle perspective.

5 References

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6 Acknowledgements

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